US Army Corps of Engineers
Detroit District

FEASIBILITY STUDY FOR THE BOARDMAN RIVER

GRAND TRAVERSE COUNTY, MICHIGAN

APPENDIX F – MONITORING PLAN

GREAT LAKES FISHERIES AND ECOSYSTEM RESTORATION PROGRAM

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1 Introduction and Rationale for Monitoring

Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure, that when conducting a feasibility study for a project under the U.S. Army Corps of Engineers ecosystem restoration mission, that the recommended project include a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction to which adaptive management, if needed, should proceed. This monitoring plan includes a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, the estimated cost and duration of the monitoring, and a discussion of adaptive management.

A monitoring plan is an important tool to help establish post-construction success of an ecosystem restoration project. Monitoring provides data to compare pre- and post-project conditions, allowing one to gauge the success of the project, and/or recognize when or if implementation of adaptive management is necessary to achieve the project objectives. The monitoring plan for the Boardman River Ecosystem Restoration project would be cost shared between the U.S. Army Corps of Engineers, Detroit District (USACE) and Grand Traverse County, Michigan for up to 10 years as expressed in the Project Partnership Agreement (PPA) or until the District Commander deems success of the project. A decision point for success of project objective would be made during monitoring year 3 and, if necessary, years 6, 8, and 10. The duration of monitoring may be lengthened if adaptive management becomes necessary to achieve the project objectives. This monitoring plan targets three years of activities.

The purpose of monitoring is to provide actionable information to assess whether the proposed action achieved project objectives. The objectives for this project are:

This study evaluated alternatives for reconnecting and restoring tributary habitat of the Boardman River to meet the following objectives:

- Restore the natural balance between coldwater and coolwater species throughout the study area;
- Allow unimpeded movement of woody debris and sediment materials through the river system;
- Negate thermal disruption;
- Reduce water temperatures in the impoundments;
- Facilitate the passage of various fish species up and downstream; and
- Prevent passage of invasive species further upstream

Achieving these objectives would require removal of the dam and permanent restoration of the river back to natural conditions. This would allow for fish passage and reconnect segments of the Boardman River. In addition, the warming effects of the dams and their impoundments would be removed and water temperature would decrease and dissolved oxygen concentrations would increase. Thus, coldwater habitat in the Boardman River would increase.

Adaptive management is an iterative process (Figure 1) that integrates results and analysis of long term monitoring with adjustments to project operation to inform environmental protection and operational efficiency decisions. This adaptive management plan (AMP) describes how the restoration of the Boardman River would be adjusted if long term monitoring finds adverse impacts from the dam removals and channel restoration. It describes the process for evaluating the results of the monitoring program, membership and responsibilities of the interagency team, "triggers" or action points that would necessitate a restoration corrective action of the project and potential changes that would be implemented to mitigate adverse impacts.

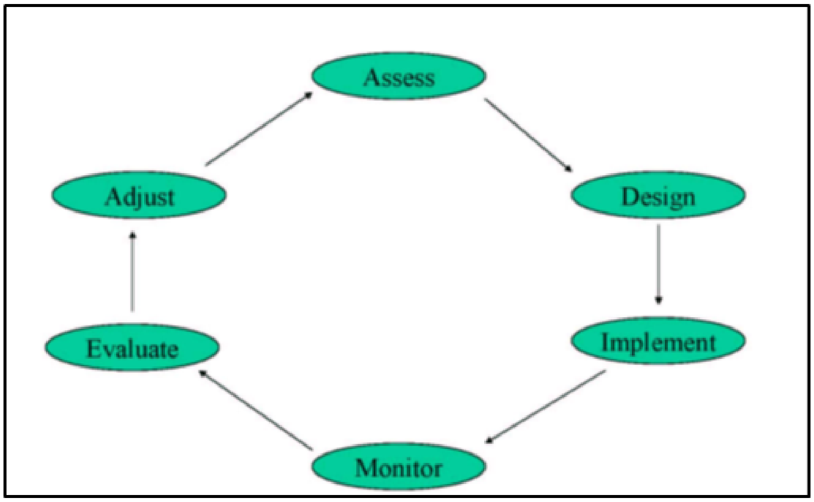

Figure 1: Six Steps of Adaptive Management (from USACE)

2 Post Construction Monitoring

Key project specific parameters to be measured were identified based on their relevance to determining whether project objectives were met.

Project Specific Parameters for Monitoring

- Temperature and dissolved oxygen (DO)
- Monitoring of channel and habitat structure stability
- Fish sampling for species identification
- Monitoring of sea lamprey (*Petromyzon marinus*) population
- Wetland restoration monitoring

2.1 Temperature and DO Monitoring

Temperature should be measured using a water temperature data logger during the months of June through August at a location upstream of the former Boardman Dam impoundment, a location between the former Boardman and Sabin Dam impoundments, downstream of the former Sabin Dam impoundment, and at the river's confluence with Boardman Lake. Suggested monitoring locations include at Beitner Road, Cass Road, near Laura Drive, and at Airport Road. The data loggers would record hourly measurements of water temperature at all locations during the summer months for a minimum of 3 years. Determine if the measured downstream temperatures exceed the upstream temperature by more than the 2.0 degrees F allowed under Michigan Surface Water Quality Standards. If the downstream temperatures do not exceed the upstream temperatures by more than 2.0 degrees F plus the accuracy of the monitor, then the project goals have been met.

DO and temperature data would also be measured manually by performing cross sectional surveys of the river at each of the stations when the temperature data loggers are installed and retrieved each summer and during monthly maintenance visits. DO and water temperature readings would be taken every 3 feet in the middle of the water column using a handheld sonde. Collected data would be used to compare river temperatures and DO above and below the former impoundment. The temperature and DO measurements at each downstream location should be similar, within approximately 2 degrees Fahrenheit and 2 mg/L DO at all stations.

2.2 Channel and Habitat Monitoring

Channel and habitat structures within the restored stream segments should be inspected regularly. After construction is complete habitat and grade control structures should be inspected for a minimum of three years. The purpose of the inspections would be to identify whether the habitat structures are remaining in place and whether grade control structures and engineered riffles are providing substrate required for spawning. The location of structures should be recorded to sub meter accuracy. Movement or burial of structures should be less than 1 meter. Channel and habitat inspections can occur during installation and removal of temperature data loggers.

Under the no action alternative, Boardman and Sabin Dams prevent the natural transport of fluvial sediment to Boardman Lake. Removal of these dams under the recommended alternative would restore natural sediment transport downstream to Boardman Lake. While the amounts and volumes of natural sediment transport from a forested watershed, with high infiltration capacity are quite low, periodic inspection of a couple key locations should be included as part of this monitoring plan. The two locations are the culverts at Airport Road, and where the Boardman River empties into Boardman Lake (hereafter referred to as the Boardman Delta). Inspections of these areas should be undertaken to verify sediment transport processes are functioning to move sediment through the culverts, culverts are not obstructed by large wood, and sediment is moving into Boardman Lake, the natural location for their deposition.

Inspections of the Airport Road culverts and Boardman Delta provide two purposes. First, an initial inspection, to document conveyance, culvert, and channel conditions prior to any work associated with the recommended alternative. The second is for periodic, ongoing monitoring to repeat these inspections and observe for any potential change in conveyance at these locations (from accumulation of woody debris, and/or sediments). As there is recent survey data already provided as part of this study, no further survey data are required to conduct the initial inspection. However, a visual inspection and photographic record of the existing conditions at the culverts and delta should be undertaken. The photographic record should be established from fixed locations and with fixed view angle, scope, and area following established photographic survey criteria (e.g. Hall, 2001). This inspection should occur under representative flow conditions (e.g., during baseflow in the summer months as opposed to during or following a large flood event). In addition, inquiries with the city and county should be made to determine the history and frequency of any required culvert cleaning to remove woody debris and/or sediment under existing conditions. These observations, along with the existing survey data, would provide the baseline condition. During and following dam removal, inspections should be repeated at least two times per year, ideally at the beginning of June and the end of August when the temperature data loggers are installed/removed. These inspections should be repeated for the first three years following dam removal. If no sediment issues have been identified, then the project goals have been met and the inspections can be discontinued. However if sediment transport at these locations becomes problematic, inspections would continue and adaptive management strategies would be applied.

As the culverts have sufficient hydraulic capacity to transport bedload sediment in the Boardman River, it is not anticipated that dam removal would cause any undue sedimentation impacts upstream of the culverts. However, if inspections indicate there may be ongoing sedimentation issues causing obstructions at the culverts or navigational issues with the delta, then detailed surveys should be undertaken to determine possible adaptive management measures. Note, it would be normal for periodic waves or dunes of sand to move through the system and deposited on the delta. These should be readily flushed through to deeper waters during storm or snowmelt runoff events.

Additionally, to assist with the evaluation of sediment transport and habitat downstream of the dams, two cross sections shall be established for monitoring channel geometry and gradation. The cross sections shall be located at riffles between Boardman Lake and Sabin Dam. The sections would be surveyed prior to dam removal to sub-meter accuracy, with Wolman Pebble Counts conducted if the section is wadeable. Measurements shall be performed two times per year after removal to monitor for changes in bed gradation and channel geometry.

2.3 Fisheries Monitoring

If after three summers the water temperature and DO goals have been met, fish sampling would occur at a location upstream of the former Boardman Dam impoundment, between the former Boardman and Sabin Dam impoundments, and downstream of the former Sabin Dam impoundment. Suggested locations include at Beitner Road, Cass Road, and near Laura Drive. Fish collection protocols should follow the Great Lakes Environmental Assessment Section (GLEAS) Procedure #51 Survey Protocols for Wadable Rivers (1999) used by the Michigan Department of Environmental Quality (MDEQ).

Fish should be collected using a backpack electroshocker or a tote barge with associated electroshockers during low flow conditions. Fish shocking must always be done in an upstream direction with sampling efforts ensuring that all fish species present are collected in proportion to their occurrence. As a goal, at least 100 individual fish should be examined from each stream reach, which generally requires approximately 30 minutes of electrofishing per station, encompassing 100-300 feet with sufficient sampling to include all significant available habitats. For the Boardman River, the length of the sampling station should be approximately 300 feet for segments 30 feet wide or about 5-10 channel widths for larger stream segments. If the number of fish collected is no greater than 100 individuals after 45 minutes, discontinue further sampling and calculate metrics based on reduced sample size. All collected fish should be placed immediately in water filled tubs for processing. When sampling has been completed at each station, the following information should be recorded:

1. The location of the sampling stations so that future studies can be repeated at the same station.
2. Record the names, lengths, and numbers of each species collected (with a length greater than 1 inch) and determine the total number of fish collected.
3. The following externally observable anomalies should be noted as total number of individuals afflicted: bent spine (scoliosis), open lesions, severely eroded fins, fungus patches, growths on skin or fins, tumors, and poor physical condition indicated by severe emaciation, excessive mucus coating, and hemorrhaging.

4. Record the amount of time spent electrofishing at each station including the number of passes through the sampling station and the number of shocking probes used.
5. Record average stream width (wetted stream channel width at time of sampling) and distance of reach electrofished. Catch per unit effort (CPE) would be calculated as the total number of fish collected divided by the number of minutes spent shocking at each station (catch per minute), and as the number of fish per stream area (catch per square meter).

Currently, Procedure 51 metrics are only utilized to assess warmwater and coolwater streams. Consequently, sampling data would be used to calculate a fish score based on the sum of each of the twelve coldwater metrics developed by Mundahl and Simon (1999) from Minnesota, Wisconsin, and Michigan fisheries data. The coldwater metrics are listed below:

- # Total Taxa
- # Coldwater Taxa
- # Coldwater Individuals/150 meters (or sample reach)
- % Coldwater Individuals
- % of Salmonids that are Brook Trout
- % Top Carnivores
- # Tolerant Taxa
- % Intolerant Individuals
- % White Suckers
- # Minnow Species
- # Benthic Species
- # Warmwater Individuals/150 meters (reach)

The fish scores for upstream and downstream segments of the Boardman River can be compared to see whether dam removal and stream restoration has improved the fish assemblage in the Boardman River. Success can be determined if the fish populations within the downstream sampling locations have similar species and abundances as the sampled upstream reach. Fish monitoring results can also be compared to baseline conditions provided by previous Michigan Department of Natural Resources (MDNR) monitoring that showed an increase in water temperature and reduced biomass of coldwater species below the dams. If fish assemblages in all three sampled segments are similar, then fish connectivity and habitat improvement has been achieved and the former dam and impoundment impacts to coldwater fish have been eliminated and no further monitoring is necessary. Success can also be attained if coldwater fisheries have improved compared to past MDNR monitoring. If sufficient data sets for comparing fish assemblages do not exist, success can be achieved by meeting the temperature goals.

If the fisheries present at the sampling locations are significantly different, water temperature monitoring via data loggers would continue for three more years. Additionally, benthic invertebrate sampling according to Procedure 51 would take place during monitoring year four and additional fish sampling in monitoring year 6. If it is decided after year 6 that the downstream portion of the Boardman River has not developed into suitable coldwater trout habitat after, monitoring would continue with the collecting of temperature data in years 7 and 8, benthic invertebrate sampling in year 7, and additional fish sampling in year 8. A similar monitoring schedule would be adhered to in years 9 and 10, if the project goals have not been met after year 8.

2.4 Sea Lamprey Monitoring

The USFWS currently monitors and treats the Boardman River for lamprey infestation from Sabin Dam to Grand Traverse Bay and recognizes the Union Street Dam as an impenetrable barrier. Historically, the Union Street Dam has always served as a lamprey barrier but several year classes of larval sea lamprey were discovered in the Boardman River between the Union Street Dam and the Sabin Dam in the fall of 2010. Inspection of the Union Street dam identified several gaps between the stop logs and concrete sill that are sufficient for passing sea lamprey, consequently, the river segment between the Union Street and the Sabin Dams was treated with lampricide in 2010 and 2011. The Union Street Dam was subsequently repaired and monitoring of its effectiveness as a lamprey barrier is ongoing.

Since the lamprey population is currently monitored and controlled by the MDNR and the Union Street Dam is considered a lamprey barrier when working correctly, additional fieldwork is not needed. However, annual MNDR lamprey and fisheries data would be reviewed to determine if any issues involving sea lamprey need to be addressed.

2.5 Wetland Restoration Monitoring

The newly formed wetland areas would be monitored annually for a period of three years, then every three years until deemed successful. Wetland monitoring would occur starting one full growing season after the planting and seeding of restoration areas.

During each site visit, a wetland investigation would be performed in accordance with the USACE *Wetlands Delineation Manual* (Environmental Laboratory, 1987), the USACE *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region*, Version 2.0 (USACE, 2011), and the MDEQ *Michigan Wetland Identification Manual* (MDEQ, 2001). The following information would be collected during monitoring fieldwork:

- Delineation of wetland habitat within restoration areas;
- Hydrology measurements in each wetland type;
- Plant species identified during monitoring;
- Invasive species identified within the restored wetlands;
- Soil data within restored wetlands, adjacent wetlands, and upland areas;
- Description of any open water areas, bare soil areas, areas dominated by invasive species, and/or areas without predominance of wetland vegetation;

- Documentation of wildlife usage within the restored wetland and adjacent areas; and
- Photographic documentation of the development of the restored wetlands from each monitoring event.

Additionally, the wetland boundaries would be mapped to calculate wetland acreages by using a Global Position System (GPS) unit with real-time data correction and sub-meter resolution. Revegetation of the former impoundment areas, whether through natural succession or by wetland plantings and seeding, would be noted along with any invasive species issues. Any issues within the wetlands areas would be addressed in the adaptive management plan.

The Michigan Routine Assessment Method (MiRAM) would be used to describe the wetland resources and to qualitatively assess the value and functions of impacted wetlands (MDEQ, 2010). Developed by the MDEQ, MiRAM is a rating system meant for comparing a wetland’s functional value to other wetlands in Michigan, regardless of ecological type. The MiRAM evaluation contains two rating systems, the Narrative Rating and the Quantitative Rating. The Narrative Rating identifies the wetland types with exceptional ecological value, which automatically rates the wetland as high functional value. If the wetland is not identified as having high functional value by the Narrative Rating, then the Quantitative Rating must be completed. For data collection purposes, those wetlands rated as high functional value in the Narrative Rating can also be scored using the Quantitative Rating, but these wetlands would be considered to have high functional value regardless of the results of the Quantitative Rating. This process provides a quality and importance score for wetlands.

The Quantitative Rating is a series of metrics designed to provide a numerical score that reflects the total functional value of a wetland, which includes a wetland’s ecological condition (integrity) and its potential to provide ecological and societal services (functions and values). The following are metrics included in the Quantitative Rating:

- Wetland Size;
- Wetland Scarcity;
- Average Buffer Width around the Wetland;
- Intensity of Surrounding Land Use;
- Sources of Water;
- Connectivity;
- Duration of Inundation/Saturation;
- Alterations to Natural Hydrologic Regime;
- Substrate/Soil Disturbance;
- Habitat Alteration;
- Habitat Structure Development;
- High Ecological Value;
- Forested Wetland;
- Urban/Suburban Wetland;

- Low-Quality Wetland;
- Wetland Vegetation Components;
- Open Water Component;
- Coverage of Highly Invasive Plant Species;
- Horizontal (Plan View) Interspersion;
- Habitat Features; and
- Scenic, Recreational, and Cultural Value.

2.6 Disposition and Analysis of Information

The information gathered as part of the monitoring program should be collected in coordination with the MDNR to insure consistency and comparability with previously collected data. Results of the temperature, dissolved oxygen, sea lamprey analysis, fish and benthic invertebrate sampling, and wetland monitoring should be recorded and reported annually to the USACE and project stakeholders. The data should be presented in well organized and easy to follow excel spreadsheets that are accompanied by a narrative explaining the results and discussing whether they indicate the project is achieving its objectives. After 3 years of monitoring river channel habitat, temperature, DO, sea lamprey, and wetlands and one year of fisheries monitoring, results should be reviewed and compared to baseline data to determine if evidence exists to determine project success. Three years is considered the minimum time required to determine success for this type of project. The excel spreadsheet and narrative should be updated annually to assess project success.

2.7 Cost of Monitoring

Total cost per year for the first three years of monitoring would be approximately $10,000. Refer to "Monitoring Objectives" above for details pertaining to schedule and number of survey events. Anticipated equipment needed for the survey may include: shocking equipment including a backpack electroshocker or tote barge with electroshockers, safety gear, temperature data logger, GPS unit, measuring devices, camera, fish holding pens, work surface and hand held water quality sonde. It is expected that a fish survey (including upstream and both downstream sites) could occur within two field days.

It is fully anticipated that the project objectives would be met after three year of monitoring. However, the following table details monitoring cost for the potential ten years of monitoring.

Table 1: Monitoring Costs

Year	Parameters to Monitor	Costs
1	Wetlands, River Channel, Water Temperature, DO, Sea Lamprey	$10,000
2	Wetlands, River Channel, Water Temperature, DO, Sea Lamprey	$10,000
3	Wetlands, River Channel, Water Temperature, DO, Sea Lamprey , Fish	$10,000
4	River Channel, Water Temperature, DO, Sea Lamprey, Benthic Invertebrates	Only Required if Goals Not Met
5	River Channel, Water Temperature, DO	
6	Wetlands, River Channel, Water Temperature, DO, Sea Lamprey, Fish	
7	River Channel, Water Temperature, DO, Sea Lamprey, Benthic Invertebrates	
8	River Channel, Water Temperature, DO, Sea Lamprey, Fish	
9	Wetlands, River Channel, Water Temperature, DO, Sea Lamprey, Benthic Invertebrates	
10	River Channel, Water Temperature, DO, Sea Lamprey, Fish	
	Expected Total Monitoring Costs (3 years)	**$30,000**
	Maximum Total Monitoring Costs (10 years)	**$100,000**

2.8 Party Responsible for Monitoring

The nonfederal sponsor is responsible for performing or having the monitoring performed via a contractor. Monitoring expenses are cost shared as specified in the PPA.

3 Adaptive Management Plan

Adaptive management is the process of using post action monitoring data to determine whether additional actions are required to meet project objectives. Adaptive management needs to be driven by the information gathered during post action monitoring. It is expected that by the third year sufficient information would be available to determine whether the project was a success.

Adaptive management measures are not expected to be needed as the proposed ecosystem restoration project is well understood and readily predictable. There is a high level of agreement among the resource agencies and other involved parties that the proposed restoration would effectively provide the desired goals within the constraints of the existing ecosystem restoration project. The desired outcome of this restoration is well understood by the parties involved and is easy to predict and measure. The nature of this project and the project design combine to provide a high level of confidence that the project goals would be achieved.

The probability of failure to meet the project goals is very low. The major items of concern for project function are:

1. Portions of the dams remain below grade, or older dam remnants exist and are exposed by scouring to create a shallow pool and restrict fish passage.
2. Sufficient density of trees/live stakes are installed, such that their canopies provide shade during the warm months and limit warming of the stream and depressed dissolved oxygen.
3. Habitat and grade control structures move due to the forces of the stream and are buried and or displaced.
4. Invasive species colonize the former impoundment areas and newly formed wetland habitat.

These are not adaptive management items but are part of construction, operation and maintenance of the project. Item 1 would be addressed by the final project plans and specifications and verified during construction. Item 2 would be addressed in the final project plans and specifications and would be managed in the field to ensure sufficient density of plantings to provide shade via canopy for the stream. Item 3 would be addressed in the project Operations and Maintenance manual, which would require annual project inspections, including observations of habitat and grade control structures among other project aspects. Item 4 would be addressed during construction through wetland and riverbank plantings and seeding. Post-construction wetland monitoring would identify and invasive species issues and recommend species-specific management techniques.

Detailed adaptive management actions need to be devised based on the monitoring data; however, suggestions for mitigating high water temperatures, low dissolved oxygen, sediment transport issues, lack of fish diversity, or invasive species colonization are as follows:

- Plant more and/or more mature trees along the riparian corridor. More trees would provide greater shading and cool the water temperatures. Monitoring of the conservation easement is critical to insure that riparian property owners are maintaining the desired vegetated strip. This would lead to decreased water temperatures and higher dissolved oxygen levels.
- Observe and record the location and condition of engineered structures and inspect the stream bottom for obstructions uncovered during the natural scour and deposition events that occur. If any obstructions are uncovered these should be removed. Structures placed for habitat or grade control should be observed. If they are non-functioning and fish species are not rebounding they should be replaced.
- Re-seed or re-plant areas with exposed soils, routine application of growth agents like fertilizers or water, and actively manage invasive species. Depending on the specific invasive species, management techniques may include manual removal, pesticide application, prescribed burns, and/or biological controls.

Detailed adaptive management actions would need to be devised based on the monitoring data. Adaptive management actions must be tailored to the specific issues encountered and may vary depending on the magnitude of the discrepancy between post-construction conditions and desired conditions. Therefore, the specifics of the adaptive management actions would involve a multi-disciplinary group that includes, at a minimum, the MDNR, the non-Federal sponsor and the USACE. Adaptive management costs are a non-Federal expense under Section 506 guidelines.

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